ELECTROMECHANICAL ACTUATOR FOR THE REGULATION OF THE TURBOCHARGER OF INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

The invention concerns an electromechanical actuator with which one can adjust the turbocharger of internal combustion engines.

It is known that turbochargers for internal combustion engines need a regulating apparatus to regulate the exit pressure of the compressor.

Said apparatus is activated by an actuator controlled by the engine's electronic control unit (ECU), or by another equivalent system. The aim is to supply the necessary power to move or maintain the turbocharger's regulation levers in the correct position. To maximize the efficiency of the turbocharger at each change of the engine's operational regime, it is indispensable that the regulation of the exit pressure of the compressor be the quickest and most precise possible, with reference to the signals from the ECU or any other equivalent electronic system, hereinafter called for simplicity's sake electronic control unit.

Independently from the way in which the compressor's exit pressure has changed, therefore either in the "waste gate" type of solution, or in the solution in which the inclination of the turbine's stator blade (variable geometry turbocharger), said adjustments are normally carried out through the linear sliding, or nearly linear, of a pilot point.

At the present state of the art the most common systems for the carrying out of the regulation of the turbocharger are two:

- the first is a pneumatic type and it covers about 99% of the applications;

- the second, called REA (Rotatory Electric Actuator), the object of the U.S. Patent No. 6,360,541B2, is of the electric type.

The pneumatic type actuator, the first type, is composed of a single effect jack - comprising a sealed chamber, a membrane and a piston with a spring - which functions in compression or in depression.

The control of the turbocharger by the engine's electronic control unit is indirect or may be even absent when in the turbochargers with connection and pressure catch directly from the crankcase of the compressor.

In fact the signal transmitted by the engine's electronic control unit inflects an electric valve which, by acting on a constant pressure tank, adjusts the pressure or depression values that must reach the actuator which, consequently, controls the pilot point. Said system, although relatively economical, carries the following disadvantages:

- it is imprecise due to the plurality of levers and of the non negligible relevance of the internal frictions which also determine a hysteresis of the same system;

- it is slow, due to the pneumatic activation, therefore, when there are sudden changes in the engine's regimen, the fluid dynamic transients constrain the system's response capacity;

- it requires a dedicated pneumatic system with connectors, tank and regulation electro-valve which change with the change of the engine on which said actuator is applied.

The REA type actuator, the second type, comprises an electric motor and a speed reduction group with a rotating exit. The control system interacts with a plurality of sensors among which the exhaust gas recirculation system

(EGR) to co-ordinate the operations of the turbocharger with those of the engine and the EGR.

Said REA type actuator therefore:

- requires an electric motor with reduction group which limits its speed and increases the exit torque to make it appropriate for controlling the pilot point;
- it needs a plurality of control connections which require specific adjustments for its use with different engines;
- it moves into the "hot spot" the electronics related to a series of activities which, in other types of actuators, are normally carried out by the engine's electronic control unit;
- it is rather complex and therefore costly.

SUMMARY OF THE INVENTION

The aim of the present invention is the creation of a device with which one can operate on the regulation of the turbocharger of internal combustion engines, therefore a device with which to command the pilot point. Said device must be structurally simple, efficient and easily applicable to engines which differ. Another aim of the invention is that of achieving a device which reduces the complexity of the motor mechanism as a consequence of its introduction. Another aim of the invention is that of achieving a device with a linear movement, or one that is nearly so, of its control element that must be connected to the pilot point so as to simplify its installation and the transmission of the forces and the movement to the said pilot point.

Finally one more aim, is the creation of a device which is not encumbered

by hysteresis error, which has very short reaction times to the commands it receives, so that it increases the efficiency and flexibility of the engine-turbocharger system.

The invention which has allowed us to reach these results is obtained by the combination of:

a) an electromechanical group comprising a solenoid that generates a magnetic field, provided with a ferromagnetic nucleus sliding inside it, combined with a rod capable of interacting with the pilot point of the turbocharger, furthermore supplied with a sensing system for the position of the ferromagnetic nucleus inside it;

b) an electronic circuit which: - on the way in receives at least the signal from the electronic control unit of the engine and the retroaction signal or the feedback signal connected to the position of the ferromagnetic nucleus of the solenoid; - on the way out it supplies the electric current connected to said entry signals and with which it feeds the solenoid generating said magnetic field.

Such an invention is particularly advantageous since it is constructively very simple, it is efficient and, above all, it is very versatile in the sense that it is easily applicable or adaptable to different engines.

Another advantage of this invention is owed to the fact that it reduces the complexity of the engine plant, given that it does not use pneumatic groups and it does not require connections to particular sensors distributed in the vehicle and capable of registering, instant by instant, the operative conditions.

Another advantage derives from the fact that the organ which is intended

for the actuation of the pilot point, that is the rod combined with the ferromagnetic nucleus sliding inside the solenoid, during its operation is subject only to axial sliding, so that it is easy to connect to the pilot point and, at the same time, it facilitates the connection of the mechanical structure of the solenoid on the turbocharger piloted by it or on another part of the engine.

Another advantage derives from the fact that frictions are very limited, therefore the hysteresis effects which they tend to generate are practically null and in any case, instant by instant, are compensated, given that the position of the ferromagnetic nucleus and therefore the activation extent of the turbocharger is linked to the feedback signal, which allows the necessary compensations. Furthermore, the response to operative variations of the engine is immediate and almost instantaneous, and in any case the response time is minimal, allowing in this way a continuous optimal regulation of the pressure exiting from the compressor group of the turbocharger.

Other advantages will appear obvious to the operators of this field by reading the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will in fact be easily understood in its functional logic by the detailed description which follows and which refers to the block diagrams and the schematic drawings which exemplify the preferred embodiments of the said invention.

In the drawings:

- Fig. 1 reproduces the block diagram exemplifying the operation of the

invention;

- Fig. 2 exemplifies the embodiment in which the sensor which detects the position of the ferromagnetic nucleus in the solenoid is made with an electric resistor which acts as a potentiometer;

- Fig. 3 is the electric circuitry exemplifying the invention;

- Fig. 4 is the front view of the electromechanical group, partially sectioned, showing the structure of the solenoid, of the sensor which detects the position of the ferromagnetic nucleus made with a resistor element, as well as of the attachment of the said group to the body of the turbocharger.

It is understood that the drawings are of the schematic type, with the aim of facilitating the comprehension of the invention, without constituting, in any way, a limitation to it.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In substance, the invention therefore consists of an electromechanical actuator with which, on the variation of the engine's operational conditions, the operational conditions of at least the turbocharger, through which the supercharging of the same engine is regulated, are changed.

The actuator, the object of the present invention, through which the pilot point of the turbocharger is activated, is made up of a combination of an electromechanical group and of an electronic regulation and control circuit.

The electromechanical group, schematized in figure 4, comprises the solenoid 1 provided with a ferromagnetic nucleus 2, normally created with a ferromagnetic material having minimal hysteresis.

Said ferromagnetic nucleus , slides within the said solenoid 1 and is

furnished with a rod 3 that interacts with the pilot point 4 of the turbocharger 5.

The ferromagnetic nucleus 2, in the solution exemplified in the drawing, through lever 6 activates the sensor 7, intended to register and notify its position. In said solution sensor 7 is of the resistive type and operates, for example, as shown in fig. 2. For instance, lever 6 of fig. 4 supports electric contacts 20, capable of interacting with resistance 10, normally of the linear type. At each instant, the electric contacts 20 define therefore the position occupied by the ferromagnetic nucleus 2 in solenoid 1. In another embodiment the sensor 7 is made with a capacitive group. In still another solution sensor 7, that is the device through which the control of the ferromagnetic nucleus 2 in solenoid 1 is carried out, operates through a group which measures the inductance of the same solenoid 1 which changes on the variation of the amount of penetration inside it of the ferromagnetic nucleus 2.

Different sensors 7 can therefore be adopted to furnish, in any case, an exit feedback signal connected to the position of the ferromagnetic nucleus 2 with respect to solenoid 1. The reference position, therefore the starting point of the ferromagnetic nucleus 2 in the embodiment exemplified in fig. 4, is constituted by the stop plate 12, against which ferromagnetic nucleus 2 is pushed by the compression spring 8, wrapped around rod 3.

The electronic circuit, shown in figures 1 and 3, receives on the way in, at least the signal from the engine's electronic control unit, or by another equivalent system, and through sensor 7 the retroaction or feedback signal, connected with the position of the ferromagnetic nucleus 2 of solenoid 1. On

the way out, said electronic circuit, emits the electric current sent to solenoid 1, tightly connected to the two entry signals. The regulation and control of said electric current permits the regulation and control of the magnetic field produced by solenoid 1 and therefore the position of ferromagnetic nucleus 2.

At each issue of electric current sent to solenoid 1, therefore corresponds a position of the ferromagnetic nucleus 2 and a correspondent state of activation of lever 21, or of other regulation means typical of the turbocharger 5, terminating in pilot point 4.

The electromechanical group is provided with the appropriate means 11 for its anchoring on the turbocharger 5 or on the engine to which the said turbocharger is applied. Means that can in any case vary abundantly at the change of the engine on which the invention is applied. Said means, normally, are of the flange type as exemplified in figure 4.

Solenoid 1 of said electromechanical group can have any type of structure. Normally, it consists of a coil, with one or more layers, manufactured with conducting wire, normally of copper, sheathed and/or coated with appropriate insulating material so that it can even be lodged in points which, during the operations of the engine, can reach relatively high temperatures.

Said solenoid 1 operates as a magnetic inductor and is combined with the ferromagnetic nucleus 2 with which rod 3 is joined and through which pilot point 4 is activated.

Said ferromagnetic nucleus 2, in the exemplified electromechanical solution, is also joined to lever 6, which activates sensor 7. Said lever 6, at its

free end, is normally equipped with high conductivity electric contact means 20, which rub on resistor 10, normally of the linear type, so that on the sliding of the ferromagnetic nucleus 2, said contact 20 will slide in a guided way on resistor 10, allowing the collection of a portion of the signal present at the ends of said resistor 10, with which it signals, to the programmed electronic control group, the exact position of the ferromagnetic nucleus 2 in solenoid 1. This allows to control instant by instant, for example, the sliding of the ferromagnetic nucleus 2 which is required to cancel the eventual hysteresis effects.

The electronic circuit with which the current in solenoid 1 is controlled and adjusted, and therefore the movement of pilot point 4, at the variation of the operational conditions of the engine, is constituted of two parts, as exemplified in the figures 1 and 3. A first control part 14 which is constituted, for example, by a programmable micro controller, and a second part 15 of power with which solenoid 1 is fed with an intensity of current that can even reach various amperes.

The control part 14 carries at least two entrances from which it receives in one, the signal of the engine's electronic control unit, defining or in any case proportional to the operational state of the engine, in the other one, the feedback signal from the control sensor 7, controlled by the ferromagnetic nucleus 2 sliding in solenoid 1. This last signal allows, instant by instant, to know the position of the ferromagnetic nucleus 2 in the solenoid and therefore the position of the pilot point 4 of the turbocharger.

The electric circuit, in the embodiment reproduced in figure 3, is constituted therefore of a first part 14 comprising a differential amplifier unit which

receives on the way in, the signal of the engine's electronic control unit and the retroaction or feedback signal amplified by amplifier 18 and originating from sensor 7. It furthermore comprises the group 19, with which the temperature compensation is operated, so as to make the invention not influenced by the operational temperature conditions.

To said first part 14, follows the second part 15, or power part, with which solenoid 1 is controlled.

In the present invention, therefore, the operational state of the turbocharger is guided through an inductor solenoid electromechanical group, whose activation current is guided by the ECU type electronic control unit, or any other equivalent one, with a correction produced by sensor 7 which indicates, instant by instant the position of the ferromagnetic nucleus 2 in solenoid 1 and therefore the position of the pilot point 4.

In the production phase the manufacturing details may also change, as long as the operational logic governing the invention remains the same, as defined by the following claims.

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